Claims

1. Pump (1) for delivering precisely determined, small liquid flows, more particularly flows up to maximally 5 ml/min, comprising at least one pump device (8) including a piston (8) that is movable in a displacement chamber (89), the piston being provided with at least a first, foremost seal (70) for sealing the piston against the displacement chamber, and the first seal comprising a sealing element (72) with a sealing lip (73) surrounding the piston, wherein the sealing lip's first surface is prestressed against the piston by means of a spring-elastic element (74) resting on the opposed second surface of the sealing lip, the second surface being in contact with the displacement chamber, characterized in that the sealing element (72) and the spring element are essentially C-shaped in cross-section and a filling body (83) that is essentially incompressible under the operating conditions is disposed therein in order to reduce the dead space of the pump device resulting from the seal.

2. Pump according to claim 1, characterized in that the width of the slot in the C-shaped profile is essentially equal to the height of the interior of the C, such that the filling body (83) is axially insertable into the spring element (74) and substantially fills out the interior of the C at least preponderantly and preferably nearly completely.

3. Pump, particularly according to one of claims 1 to 2, for delivering precisely determined, small liquid flows, more particularly flows up to maximally 5 ml/min, comprising at least one pump device (3) including a piston (7) that is movable in a displacement chamber (47), the piston being provided with at least a second, foremost seal (48) for sealing the piston against the displacement chamber, and the

second seal comprising a sealing lip (52) surrounding the piston, whose first surface is prestressed against the piston by means of a spring-elastic element (54) resting on the opposed second surface thereof, the second surface being in contact with the displacement chamber, characterized in that the spring element is essentially in the form of a closed, spring-elastic band whose inner side contacts the second surface of the sealing lip, and that the internal wall of the displacement chamber is located at a small distance from the external surface of the spring element in order to reduce the dead space of the pump device resulting from the seal.

4. Pump (1) according to claim 3, characterized in that the band-shaped spring element (54) essentially consists of a coil of a spring-elastic material whith the turns of the coil being wound around the sealing lip (52).

5. Pump (1), particularly according to one of claims 1 to 4, for delivering precisely determined, small liquid flows, more particularly flows up to maximally 5 ml/min, comprising at least one pump device (3; 89) including a piston (7; 8) that is movable in a displacement chamber, characterized in that the piston is operatively connected to the driving unit of the pump via a piston rod (11; 12), that the piston is connected to the piston rod via a piston adjusting device (15, 28, 31, 33, 36, 38; 16, 28, 30, 32, 36, 38), and in that the piston adjusting device between the piston and the piston rod is adjustable in length in order to be able to adjust the total length of the piston and piston rod assembly to the distance between the driving unit and the bottom of the displacement chamber, and thus the dead space.

6. Pump (1) according to claim 5, characterized in that the piston (7; 8) is mounted on the piston rod (11; 12) in a longitudinally displaceable manner.

7. Pump according to one of claims 5 to 6, characterized in that the piston adjusting device (15, 28, 31, 33, 36, 38; 16, 28, 30, 32, 36, 38) is provided with a clamping means (36, 38) allowing to lock the piston (7; 8) in a determined position with respect to the piston rod (11; 12).

8. Pump (1) according to one of claims 5 to 7, characterized in that in the piston adjusting device (15, 28, 31, 33, 36, 38; 16, 28, 30, 32, 36, 38), a spring means (32) is disposed between the piston (7; 8) and the piston rod (11; 12) such that a reduction of the total length of the piston and piston rod assembly is effected against the restoring force of the spring element.

9. Pump (1) according to one of claims 5 to 8, characterized in that in the displacement chamber (89), the bottom of the displacement chamber is in the form of a body (87) of a material that is at the most neglectably compressible under the operating pressure of the pump but sufficiently more elastic than the piston, and that fills out the cross-section of the displacement chamber completely, for allowing the piston (8) to be adjusted to an indefinitely small distance from the bottom of the displacement chamber in the upper dead center, more particularly to a substantially eliminated dead space, without the risk of damages of the piston through contact with the bottom of the displacement chamber during the adjusting procedure or in operation.

10. Pump (1) according to one of claims 7 to 9, characterized in that the piston (7; 8) comprises a bar-

shaped piston portion (19; 20) of a mechanically resistant material, more particularly a ceramic, crystalline, and/or mineral material, whose rear end is mounted in a seat of a sleeve (15; 16) such that the clamping means (38, 39) can be applied against the sleeve substantially punctually, thereby locking the latter in the piston rod (11; 12) without the risk of damaging the bar-shaped piston portion by the clamping means.

11. Pump (1), particularly according to one of claims 1 to 10, for delivering precisely determined, small liquid flows, more particularly flows up to maximally 5 ml/min, comprising at least one pump device (3) including a piston (7) that is movable in a displacement chamber (47), characterized in that the bottom of the displacement chamber of at least one pump device essentially consists of the front end of an opposed piston (58) that is displaceable in the displacement chamber such that the dead space of the pump device is adjustable.

12. Pump (1) according to claim 11, characterized in that the opposed piston (58) is provided with an adjusting device comprising a position indicator, thereby making the adjustment of the dead space in the displacement chamber detectable from the outside, more particularly readable.

13. Pump (1), particularly according to one of claims 1 to 12, for delivering precisely determined, small liquid flows under high pressures, more particularly flows up to maximally 5 ml/min and/or pressures of at least 100 bar, comprising at least one pump device (3; 4) including a piston (7; 8) that is movable in a displacement chamber (47; 49), at least one working medium access bore of the pump device being provided with a detachable connecting assembly (100, 101; 100, 102; 100, 130) including at least one pair

of sealing surfaces forming a junction that is tight to the working medium, of which sealing surfaces one sealing surface is essentially dome-shaped and convex and the other one is essentially concave and conical, and in whose center, particularly at the highest resp. lowest point, a respective opening of a channel for the working medium is provided, so that an annular contact line between the two sealing surfaces is obtained even if the channel openings are not precisely aligned to each other.

14. Pump according to claim 13, characterized in that between the sealing surfaces of at least one pair of sealing surfaces, preferably of all such pairs, a seal (117) is interposed, particularly in the form of a membrane-like element of metal or of a highly pressure-resistant synthetic material, preferably of PEEK.

15. Pump (1) according to claim 13, characterized in that at least a first and a second pair of sealing surfaces are provided and a sealing body (119) is disposed between the two pairs of sealing surfaces, the sealing body having the respective inner sealing surfaces of the two pairs of sealing surfaces formed thereon and consisting of a dimensionally stable, highly pressure-resistant synthetic material, preferably of PEEK.

16. Pump (1) according to one of claims 13 to 15, characterized in that at least a first and a third pair of sealing surfaces are provided of which the two inner sealing surfaces, each facing the other pair, are formed on a connecting body (101, 102) disposed between the other two, external sealing surfaces of the two pairs, so that the two pairs of sealing surfaces each form a tight junction with the connecting body.

17. Pump according to one of claims 13 to 16, characterized in that in addition to a pair of sealing surfaces, a pair (138) consisting of a first and a second contact surface is provided, the first and the second contact surface contacting each other, the first contact surface and the sealing surface being formed on a second connecting body (130) in the connecting assembly (100, 130), and the second connecting body being held between the second contact surface and the other one of the sealing surfaces and being fixedly connected to a duct (114) for the working medium wherein the duct communicates with the channel whose opening is located in the sealing surface of the second connecting body.

18. Pump according to claim 17, characterized in that the contact surfaces (138) are cambered and complementary to each other in order to provide a centering of the second connecting body (130) in the second contact surface.

19. Pump according to one of claims 13 to 18, characterized in that in at least one of the first sealing surface pairs, preferably in all first sealing surface pairs, at least one of the sealing surfaces (120) is provided with a concentrically stepped surface (121) in order to provide a plurality of sealing lines.

20. Pump comprising at least a first (7) and a second (8) pump device composed of a displacement chamber (47; 89) and a piston (7; 8), the pump downstream of the first pump device being operatable as a storage device of the pulsation of the first pump device, and each pump device being designed according to one of claims 1 to 19.

21. Method for adjusting the dead space in a pump (1) according to one of claims 5 to 12 or according to one of

claims 5 to 12 and one of claims 13 to 20, characterized in that the piston rod (11; 12) is moved to the upper dead center, the piston (7, 8) is advanced into the displacement chamber until the desired dead space results, and the piston is locked in the piston rod by actuating a locking device (38) of the piston adjusting device.

22. Application of the pump according to one of claims 1 to 20 and according to one of claims 11 to 12, characterized in that the opposed piston (58) is adjusted according to the intended operating pressure in order to achieve a reduced pulsation.

23. High-pressure chromatography device, particularly for HPLC, comprising a pump according to one of claims 1 to 20 as the medium pump.

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